Database and GIS Solutions Developed During the Anthrax Emergency Cleanup Response on Capitol Hill, Washington D.C.

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Description of the Situation:
After anthrax was discovered on Capitol Hill in October 2001, Tetra Tech EMI (Tetra Tech) was tasked to mobilize personnel and emergency response vehicles to Washington, D.C. to assist several government agencies in determining the level of contamination and appropriate cleanup strategies. The government agencies that Tetra Tech assisted included the U.S. Environmental Protection Agency (EPA), the Centers for Disease Control (CDC), Capitol Hill Police, Architect of the Capitol (AOC), the U.S. Coast Guard, and others. The work performed by Tetra Tech included sampling, assessment, delineation, and decontamination of anthrax-related contamination in dozens of sites on or near Capitol Hill."

As part of the cleanup efforts, Tetra Tech was also tasked to develop and maintain the Microsoft Access environmental database that tracked more than 10,000 environmental samples with their associated results. This information was used during the planning and cleanup stages to delineate areas of contamination. Maps produced from geographic information system (GIS) were used as a tool to determine the precise locations to characterize, isolate, and remediate Anthrax-contaminated areas. In addition, maps and reports generated from the environmental database were evaluated by the committee review board in charge of determining proper and complete remediation of affected building. These maps and custom reports were then used in the final report writing process.

State the problem:
The discovery of anthrax on Capitol Hill created an unprecedented shutdown of key buildings and threatened to disrupt the workings of our federal government; therefore, it was imperative to address the problem and restore normalcy as soon as possible. To achieve that goal, hundreds of biological samples were collected each day during around-the-clock site operations. Laboratories were able to provide results in as little as 24 hours. These results had to be quickly integrated with the sample data so reports and maps could be generated for immediate review. Initially, data storage was maintained in Microsoft VISIO with multiple Access databases. However, this time-consuming manual process did not have dynamic, updatable links between the databases and the VISIO maps. It was difficult to quickly retrieve information from multiple sites, or to show site cleanup progress over time. In addition, static computer-aided design (CAD) maps were used as basemaps and imported directly into VISIO, thereby losing all geo-rectified information during the process. VISIO lacks the capabilities of GIS software and was a hindrance to the required rapid site evaluations. To support the decision-makers, procedures needed to be developed for quickly creating and maintaining accurate, reliable, updatable, dynamic, easy-to-use data reports and maps.

Tetra Tech provided EPA with an alternate form of managing operations with the use of Environmental Systems Research Institute, Inc.'s (ESRI) ArcView 8.x, and a single master database with a customized user interface. This management system allowed the sample and location information from the electronic chain-of-custody (COC) to be seamlessly imported into the database. Laboratory results were easily and quickly associated with the proper samples. An easy-to-use interface was developed that allowed

nontechnical users to view and print a variety of complex reports from the database. GIS was able to dynamically link to the database and graphically depict the most up-to-date sample information.

Migration of data:
Tetra Tech acquired Bentley's MicroStation CAD files from the AOC for each affected building to use as initial basemaps. An example CAD file is shown on Figure 1. These maps showed detailed floor plans and were imported into the GIS along with sample data from the master environmental database in dBase IV format. At the initial point of migration, more than 5,000 environmental samples had been collected and were stored in the VISIO environment. In addition, more than 100 samples a day were still being collected. Quality control (QC) procedures needed to be developed to better establish actual sample locations.

To implement the QC initiative, the CAD basemaps were converted to a geodatabase format to allow dynamic adjustments to various features including walls, closets, cube areas, hallways, and furniture (Figure 2). To improve sample location accuracy, samplers were supplied with detailed maps and preprinted COCs. The samplers made notations and corrections to the maps and COCs that were later updated in the database and GIS. These updates, along with the dBase exports, provided a seamless method of entering, checking, modifying, and facilitating information flow between the environmental and GIS databases.

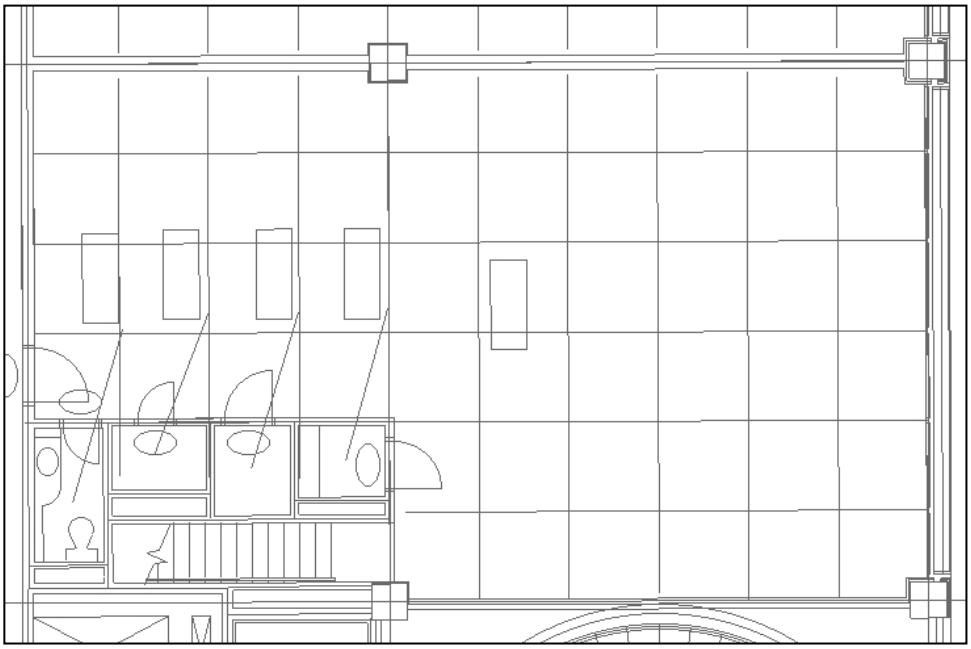

Figure 1. Static basemap from MicroStation.

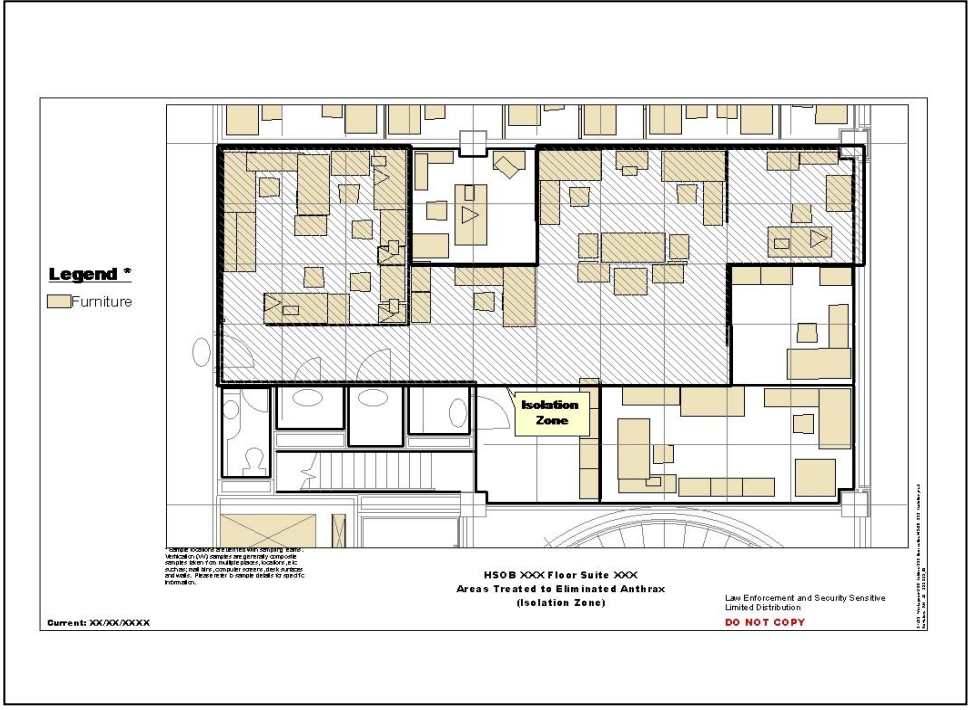

Figure 2. Dynamic Geodatabase created in ArcView.

Challenges and Implementation:
There were a multitude of sample types taken throughout the duration of the project. Some of the sample types included wipe, high-efficiency particulate air (HEPA), swab, personal air, area air, and aggressive air samples. Each of these samples had to be represented differently for sampling intent (Figure 3). To maintain data integrity and consistency, a lookup table was used to define the sample types.

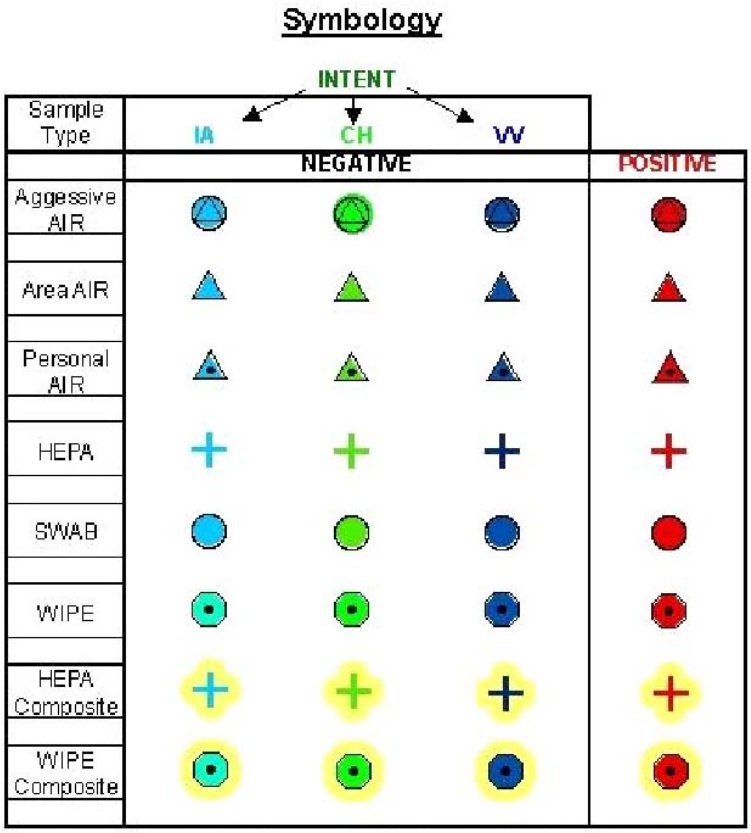

Figure 3. Symbolization methodologies

There are three primary sampling intents that define the events throughout the entire sampling process on Capital Hill. There are the (1) Initial assessment (IA), (2) Characterization (CH), and (3) Verification (VV). Hundreds of maps and database reports were produced for each step and location to better determine the extent of contamination and the effectiveness of cleanup. The details of each sample intent are described below:

- Initial assessment

  During the initial assessment (also known as the "mail trail"), sampling teams would actually follow the mail trail throughout the buildings. In each room or suite, wipe and HEPA samples were collected at the entrance and at all mail handling areas (Figure 4).

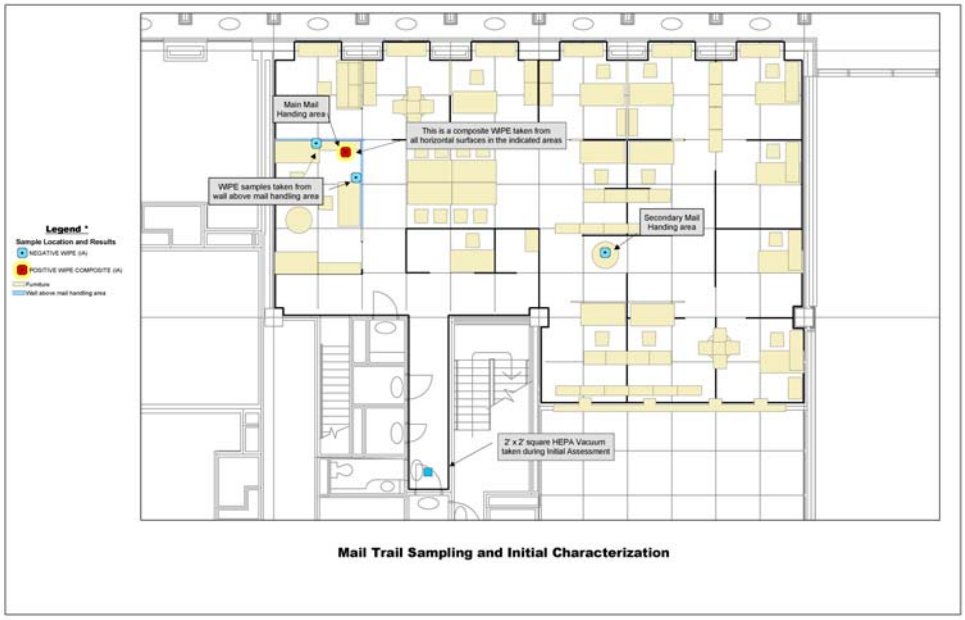

Figure 4. Mail trail sampling

- Characterization

  During the characterization phase, all rooms and areas were sampled to ensure that there weren't any unknown regions of contamination. If there were any positive results, rooms were sampled to enable an in-depth characterization and delineation of contaminants. Areas sampled include rooms that had one or more positive results during the initial assessment, and rooms that were not previously sampled (did not have mail handling areas). Figure 5 depicts an example of the in-depth characterization of a resulting positive result (from Figure 4). In this case, the contamination was remediated during the IA process.

Figure 5. In-depth characterization example.

Composite samples were taken during the "every room" effort that was part of the characterization sampling event. Each room was divided into areas and one composite wipe was collected from all horizontal surfaces in that area. Since the furniture and walls were available in the geodatabase format, these objects were dynamically represented in a customized format (thicker lines and/or colors and shapes (Figure 6).

Figure 6. Positive result during the every room sampling event.

Any positive results triggered an in-depth characterization. Figure 7 shows sample locations following the positive result on Figure 6.

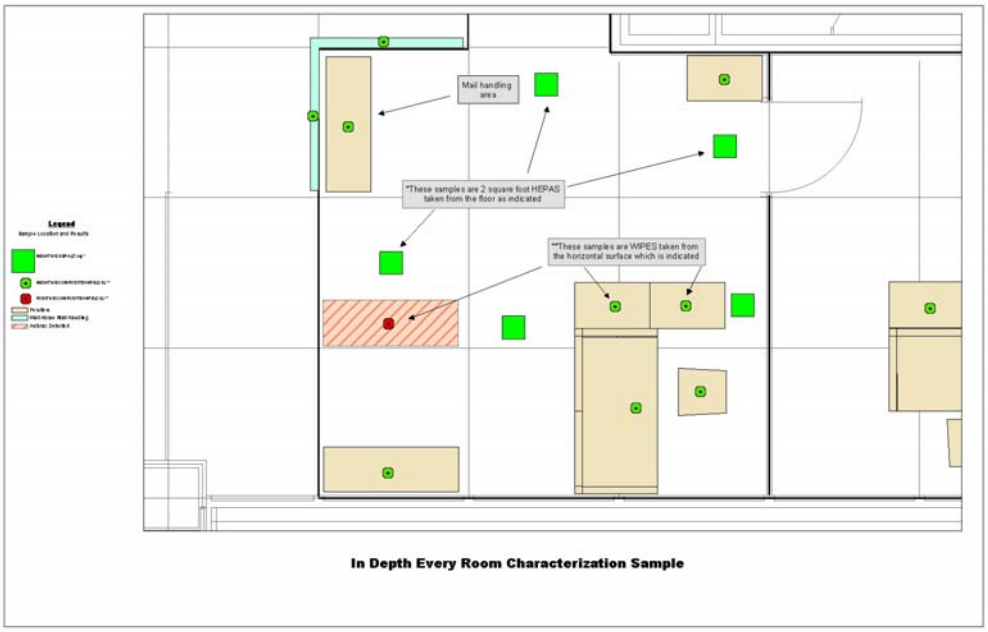

Figure 7. In-depth characterization resulting from a positive result.

- Verification

  Contaminated areas were physically isolated and remediated (Figure 8). The verification samples were taken after a remediation event to ascertain the success or failure of a remedial effort. Maps were produced to show the isolation zones and the remediation effectiveness (Figure 9).

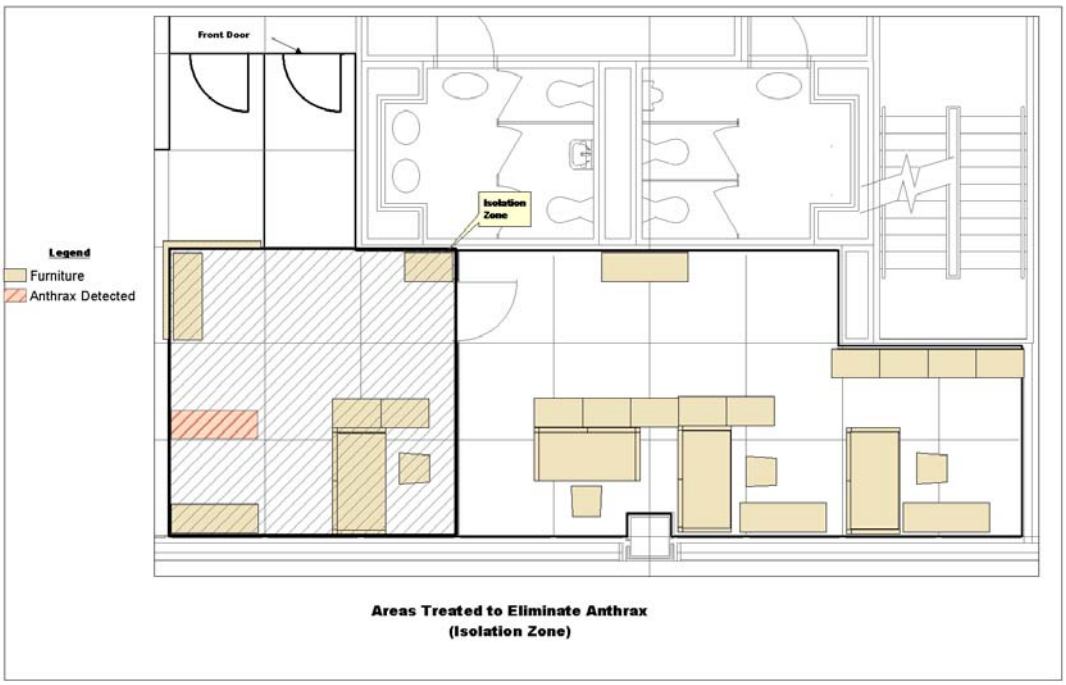

Figure 8. Isolated contamination area ready for remediation

Figure 9. Verification samples in remediated area

Hundreds of custom database queries and reports had to be run to support the sampling and cleanup decisions. Database experts were on site to manage the database, and dynamically query sample data and results. However, since nontechnical users wanted to query the database and print reports, an easy-to-use interface was developed. This interface allowed the users to view and print a number of complex reports (Figure 10).

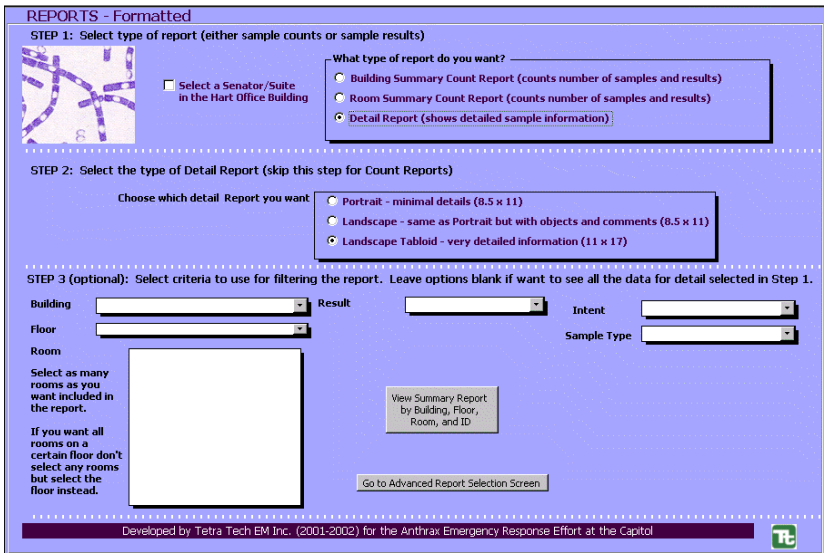

Figure 10. Custom database report interface

Using GIS with a single sample database greatly outperformed the initial VISIO with multiple databases environment. The capability to quickly query results to produce either a tabular report or to view the results graphically, and the ability to effectively keep up with the constant flow of data greatly added to the effectiveness of the on-site data management operations. Part of the quality control process was performed by cross-referencing the analytical database with GIS to ensure consistency between sample objects and locations.

Hundreds of reports and more than 1,000 maps were used to support sampling and cleanup decisions, and, ultimately, resulted in the reopening of government buildings that were closed because of anthrax contamination. The combination of using a database and GIS for the anthrax emergency response significantly shortened the time interval for evaluations. Thus, rapid, well-informed decisions could be made that protected human health and expedited the return to normalcy on Capitol Hill.